National Aeronautics and Space Administration

Overview – 2 Years of Open Rotor Testing

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Fundamental Aeronautics Program
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The NASA/FAA/GE Collaboration on Open Rotor Testing

- **Objective:** Explore the design space for lower noise while maintaining the high propulsive efficiency from a counter-rotating open rotor system.
- **Approach:** A low-noise open rotor system is being tested in collaboration with General Electric and CFM International, a 50/50 joint company between Snecma and GE. Candidate technologies for lower noise will be investigated. Installation effects such as pylon integration will be investigated in partnership with GE and the FAA.

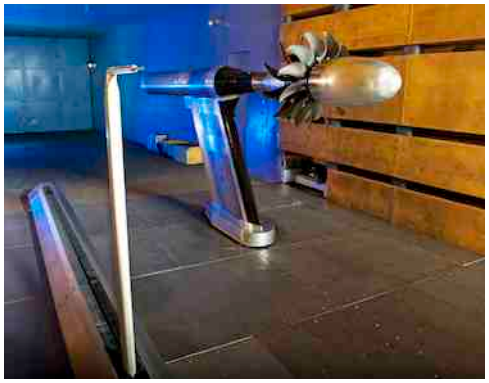
Gen-1 Blade Sets (NASA/GE)
- Historical Baseline (1990s design)
- Modern Baseline (~2006 design)
- 2 GE Advanced Designs
- 2 Snecma Designs

Gen-2 Blade Sets (NASA/FAA/GE)
- 6 GE Advanced Designs
- Pylon wake mitigation

Historical Baseline
Blade Set
12 x 10 blade count

History (1/3)

Drive rig rehab and installation



First research run. Oct 28

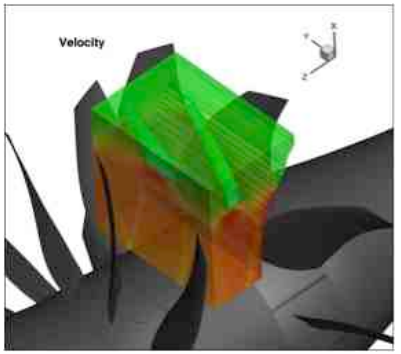
GE/Airbus entry start Dec 14

Aug	Sep	2009 Oct	Nov	Dec

Drive rig checkout. Sep 24 – Oct 27

Linear array checkout. Dec 7-11

History (2/3)



GE/Airbus test complete. Feb 12

GE/Boeing test. Apr 5 – 28.

ERA Diagnostics Test. Jul 19 – Sep 7

2010

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

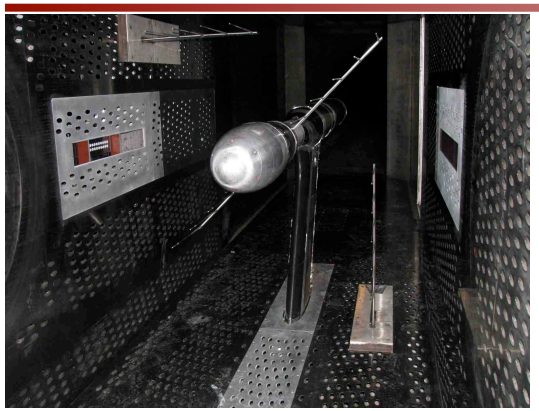
FAVOR test (ATP)

GRC annual Facility Shutdown

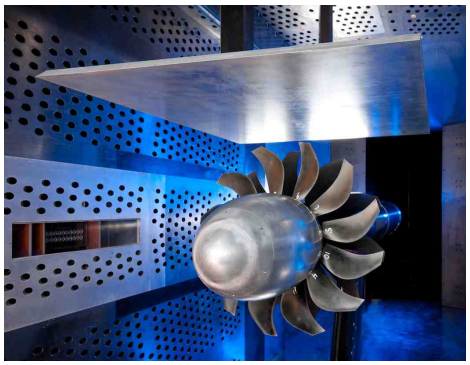
Low Boom Inlet Test (SUP)

Open Rotor Install In the 8x6

History (3/3)



8x6 Tare Runs
Feb 9



Gen-1 8x6 Test
Feb 28 – Aug 25

Gen-2 8x6 Test
Aug 26 – Sep 9

Gen-2 9x15 Test
Nov 10 – Jan 19

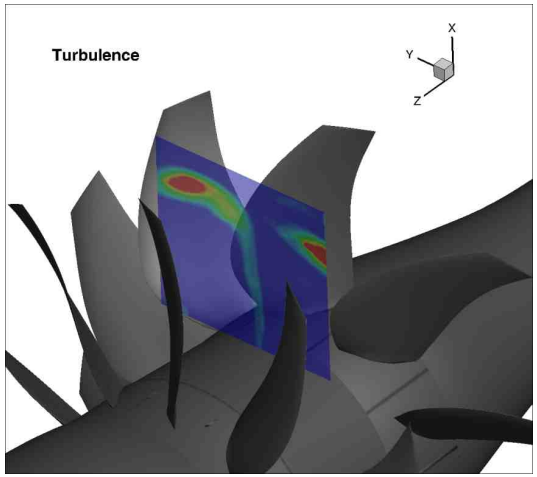
2011

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Force bal
Mar 9 an

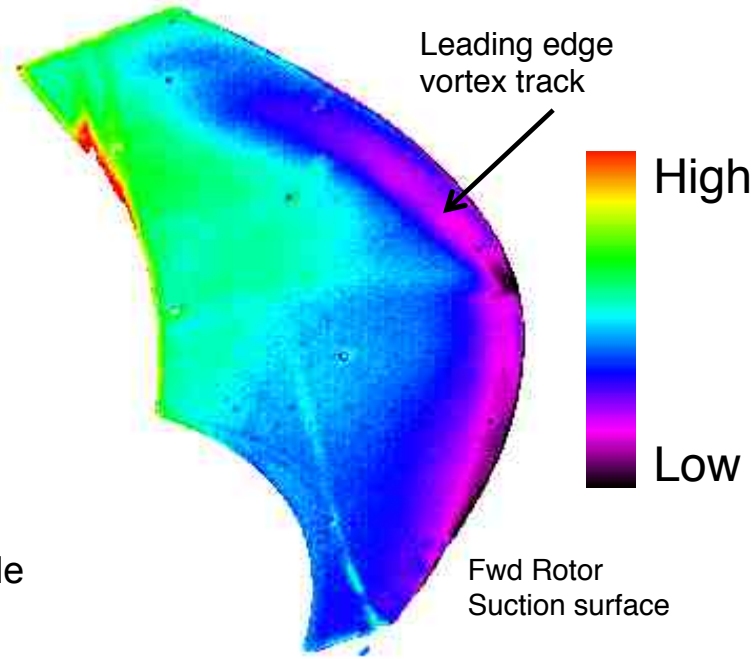
Jan. 19, 2012
End of Gen-2
Test

ERA Diagnostics:
Detailed Historical Baseline flowfield measurements



The 3D **PIV** measurements provide a wealth of information about the blade wakes and vortex track.

A canonical shielding configuration provides code validation data.



The location of peak noise level in the **phased array** map changes in the presence of the CFMI pylon indicating a change in the relative strength of sources.

The **Pressure Sensitive Paint** measurements show phase locked static pressure on the surface of the rotating blade.

Data Rights

Gen-1 Blade Sets (NASA/GE)
- Historical Baseline
- Modern Baseline
- 2 GE Advanced Designs
- 2 Snecma Designs

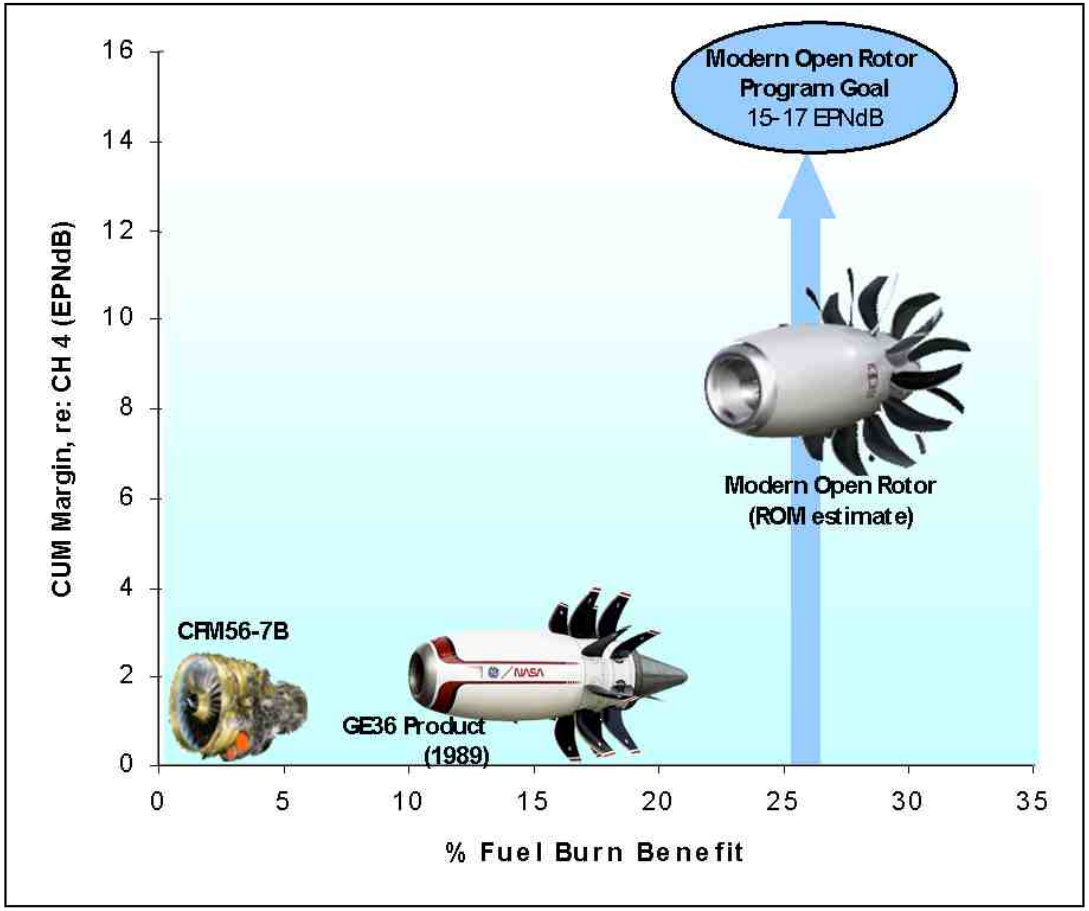
Non-proprietary geometry
Both high and low speed data is releasable/publishable.

Data/geometry for NASA internal use.
Publication in sanitized form 1 year after conclusion of test.
Low speed data is releasable in 10 years.
Geometry is releasable in 15 years.

Gen-2 Blade Sets (NASA/FAA/GE)
- 6 GE Advanced Designs
- Pylon wake mitigation

Data/geometry for government use.
Publication of data in sanitized form.

Projection of Modern Open Rotor Performance



X-Noise Workshop presentation. March 2011.

- The GE36 Product (1989) would have met CH4 noise requirements at 15% fuel burn savings.
- The modern Open Rotor design estimates are consistent with NASA system level assessments which show 25+% fuel burn and 10+ EPNdB noise margin.

Summary

The test program required a substantial commitment from the research/facilities organizations and has produced a valuable data set for the nation.

- Double shift operations, 5 days a week since Sept 2009
- 1142 hours of run time on the open rotor rig

A partnership between ERA and SFW was necessary for the success of the test and ongoing data analysis.

The collaboration with the FAA on Gen-2 blade testing worked very well.

Designs quieter than originally estimated. Margin to stage 4 is 10+ EPNdB.

THE POWER OF FLIGHT